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First records of some Asian macromycetes in Africa

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Abstract — This paper reports and discusses preliminary data on new Asian macromycete species now recorded on the African continent and collected for the first time in Niger during sampling conducted in the southwestern region from 2008 to 2012. Descriptions and comments on chorology, systematics, and closely related species are given for *Hymenagaricus subepipastus*, *Clitopilus orientalis, Tulostoma evanescens*, *Termitomyces bulborhizus,* and *Volvariella* cf. *sathei.*

Key words — basidiomycetes, fungi, taxonomy

Introduction

The literature available on the macromycetes of West Africa is generally both sparse and highly fragmented. Boa (2004) reported that there appeared to be no data at all for Niger, but since then a handful of references in local publications and international journals have cited a total of 16 fully identified species for this country (Table 1). Countries bordering this sub-Saharan region (with the exception of Mali and Chad) have recently been studied by mycologists who are beginning to publish research on the diversity, systematics, ecology, ethnomycology and use of macromycetes. As a result, much more information is now available on fungal species in Benin (De Kesel et al. 2000, 2002; De Kesel & Yorou, 2000; Yorou et al. 2002a,b; Yorou & De Kesel 2002; Yorou, 2010), Burkina Faso (Ganaba et al. 2002, Guissou et al. 2002, 2008, Guissou 2005),

Table 1. Macromycete species previously recorded from Niger.

Taxon	Reference
Agaricus augustus Fr.	Hama et al. 2008
Agaricus bulbillosus Heinem. & Gooss.-Font.	Hama et al. 2008
Agaricus subsaharianus L.A. Parra et al.	Hama et al. 2010, 2012
Crinipellis glaucospora (Beeli) Pegler	Antonín 2013a
Crinipellis pseudosplachnoides (Henn.) Singer	Antonín 2013a
Ganoderma colossus (Fr.) C.F. Baker	Hama et al. 2008, 2009, 2012
Ganoderma lucidum (Curtis) P. Karst.	Hama et al. 2008, 2009
Itajahya rosea (Delile) E. Fisch.	Hama et al. 2008
Leucocoprinus brebissonii (Godey) Locq.	Hama et al. 2008
Lyophyllum aggregatum (Schaeff.) Kühner	Hama et al. 2008
Marasmius atrorubens (Berk.) Mont.	Antonín 2013b
Phellinus allardii (Bres.) S. Ahmad	Hama et al. 2012
Podaxis pistillaris (L.) Fr.	Hama et al. 2008, 2009, 2012
Termitomyces striatus (Beeli) R. Heim	Hama et al. 2008, 2009
Trametes cingulata Berk.	Hama et al. 2008
Trametes leonina (Klotzsch) Imazeki	Hama et al. 2008

Nigeria (Zoberi 1973; Oso 1975, 1977; Adewusi et al. 1993; Osagualekhor & Okhuoya 2005; Akpaja et al. 2003; Osemwegie et al. 2006; Okhuoya et al. 2010) and, to a lesser extent, Togo (De Kesel et al. 2008, Gardt et al. 2011) and Ivory Coast (Koné et al. 2010a,b). In general, many West African ecosystems are very sparsely explored. However, Yorou et al (2014) recently updated a total list of about 72 edible macromycetes for West Africa (Benin, Burkina Faso, Ivory Coast, and Togo). In West Africa, macromycetes are not only taxonomically poorly documented, but patterns of distributions, ecology, and local use should be addressed especially in the context where forest and savannah ecosystems are disappearing at an alarming rate (FAO 2010) along with the fungal species. As an example, a preliminary Red List of threatened fungi has been published for Benin (Yorou & De Kesel 2011).

Given the lack of information regarding Niger, the University of Córdoba submitted to the Spanish Agency for International Development Cooperation a project to be implemented jointly with the Abdou Moumouni University, Niamey, entitled "Edible and cultivable Macromycetes of Niger (Ethnomycology)". One of the aims of this project was to draw up a classified inventory of Niger's fungal biodiversity. At an earlier stage, the local project team had already compiled a preliminary inventory, which was expanded and completed as part of the current research and served as a basis for the subsequent ethnomycological survey. A number of collections have been published recently (Hama et al. 2012, Antonín 2013a,b). The findings of the present study relate to the fungal diversity portion of the project and focus on the key taxonomic features of species reported earlier in Asia but which are considered first records in Africa.

Materials & methods

Material collected between 2008 and 2012 came mainly from the West Sudanian savannah (White 1986), deemed the most suitable area for a study of national macromycete biodiversity in view of its abundant vegetation; the study centered primarily on the deep-soil, wooded savannah and gallery forests bordering rivers of the W National Park in southwestern Niger. Mushrooms were mostly collected using routine sampling methods (Halling 1996, Eyi-Ndong et al. 2011); each species was assigned a collection number and photographed with a Canon 400D, Canon PowerShot G10, or Olympus U 700 digital camera. Fresh mushroom organoleptic data – colour, odour, and taste – and information on gross features likely to be modified during drying and required for identification purposes were entered on field records. Collected mushrooms were then dehydrated in situ using a Bunsen burner attached to a folding portable dryer (De Kesel 2001) and then put inside minigrip bags. Exsiccata were kept at the Abdou Moumouni University (Niamey, Niger) and duplicates were placed in the fungal section of the COFC herbarium (Thiers 2014). Some exsiccata and type material from K and BR herbaria were requested as loans to compare with Nigerien samples and also with protologues.

Colour references were coded following Kornerup & Wanscher (1981). Material was then studied under a Nikon Labophot2 light microscope fitted with a drawing tube at a 1000× magnification. Spore measurements were made in 3% KOH mounts (Menzel-Gläser) in profile position and excluding the hilar appendix and ornamentation (Lm = mean length; Wm = mean width, Em = Lm/Wm). Unless otherwise indicated, the specimens were identified by P.P. Daniëls. Species citations follow Index Fungorum (www.indexfungorum.org). Collection localities are placed in alphabetic order. For each collection, field data are ordered as follows: Country, Administrative Region, Department, Locality, Site, {Park}, latitude/longitude coordinates, altitude, ecology and substrate, date, collector and identifier (where appropriate), collection accession number, and herbarium accession number. Distribution notes have been added when this was significant compared to other African flora, and observations are included on nomenclature and taxonomy when these differ from known species descriptions.

Standard methods for DNA extraction, PCR amplification, and DNA sequencing were applied (e.g., Justo et al. 2011) to check Nigerien *Volvariella* samples due to the noteworthy morphological differences found with closely related species. Primer pairs ITS1F and ITS4 (Gardes & Bruns 1993) were used for both PCR and sequencing. The remaining sequences used in the analysis were retrieved from GenBank and come from the studies of Menolli & Capelari (2008), Li et al. (2009), and Justo et al. (2011). GenBank accession numbers are given under the specimens examined section. *Volvariella bombycina* (Schaeff.) Singer and *V. volvacea* (Bull.) Singer were used as outgroup taxa in the final dataset. These two species appear to be the sister group to all other *Volvariella* species sequenced to date (Vizzini et al. 2011). Sequences were aligned with MAFFT (Katoh et al. 2002) using the Q-INS-i strategy. The alignment was examined and manually corrected in MacClade 4.05 (Maddison & Maddison 2002) and it has been deposited in TreeBASE (http://purl.org/phylo/treebase/phylows/study/TB2:S15058). A Maximum Likelihood analysis was run in RAxML servers (Stamatakis et al. 2008) with 100 rapid bootstrap replicates.

Taxonomy

Clitopilus orientalis T.J. Baroni & Watling, Mycotaxon 72: 58, 1999. Plate 1

Macrocharacters — Basidiomata small, gregarious. Pileus 1–2.2 cm diameter, at first convex, then flat to centrally depressed; white coloured [A1] and fibrillose; margin involute and radially ridged. Stipe central or slightly eccentric, slightly turbinate, up to 10–19 × 2–4 mm, concolourous with pileus, surface pruinose, base with white mycelial tufts. Lamellae subdecurrent to decurrent, with lamellulae, 3–4/mm, white at first [A1], then brownish pink [5A3, 5B5], with whitish crenulate margin. Context fibrous; odour and taste not recorded.

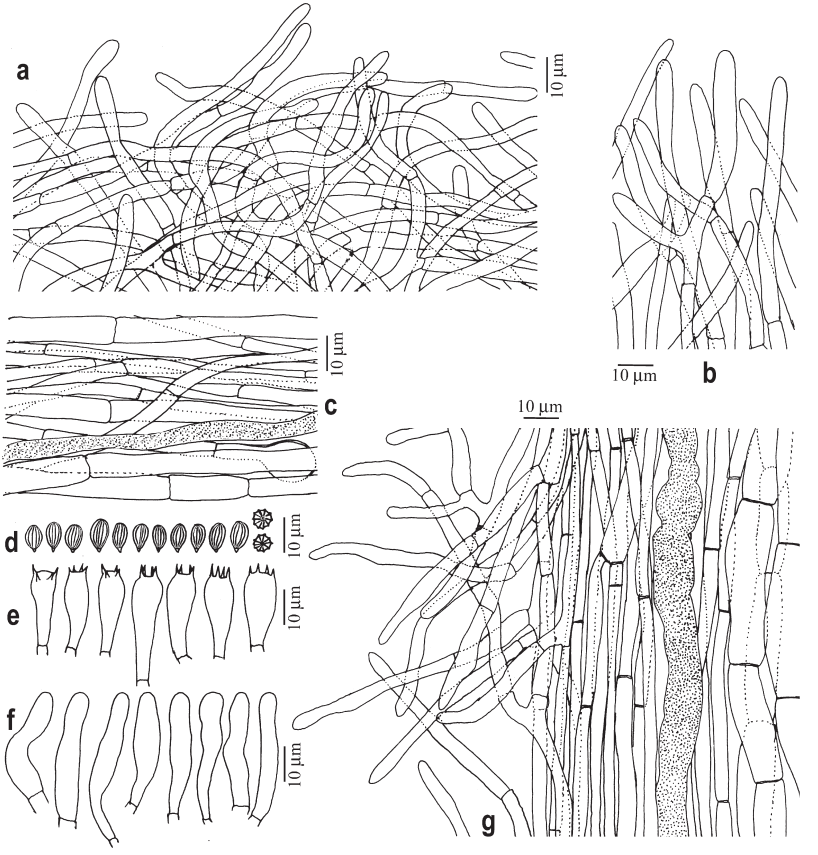

Plate 1. *Clitopilus orientalis* (COFC-F 5160):
a) Pileipellis; b) Basal mycelium; c) Pileus context;
d) Spores; e) Basidia; f) Cheilocystidia; g) Stipitipellis showing a secretory hyphae.

Microcharacters — Pileipellis made up of interlaced 3–5 µm wide elements forming a trichodermis; hyphae hyaline, thin-walled. Stipitipellis similar to pileipellis but with inner hyphae parallel, 3–13 µm wide; hyphae hyaline, thin-walled, with conspicuous septa. Context hyphae subparallel, cylindrical, 3–8 µm wide, thin-walled, sometimes with vesicular end, 12–14 µm wide, hyaline and thick-walled. Mycelial tufts with interlaced cylindrical hyphae, 4–6.5 µm wide, hyaline, thin-walled. Secretory hyphae filled with refringent content, 5–13.5 µm wide. Clamp connections absent in all structures. Cheilocystidia cylindrical to fusiform or subcapitate, 29–37(–42) × 4–8 µm. Pleurocystidia absent. Basidia claviform, 21–30 × 7–9 µm, with 4 sterigmata, thin-walled. Spores ellipsoid, striate with 10–11 longitudinal ribs, hyaline, thin to thick-walled, (6.3–)6.8–7.5(–8.5) × (3.7–)4–4.7(–5) µm, [Lm = 7.1 µm, Wm = 4.4 µm, E = 1.40–1.88; Em = 1.63].

Specimen examined — **NIGER, Dosso**, Gaya, Albarkeizé, Saboula, 12°04′55.6″N 3°14′07.5″E, elevation 136 m, fallow land beside the Niger river on a termite mound under *Anacardium occidentale* L., 13 September 2008, O. Hama, Hama 132 (COFC-F 5160).

Ecology & Distribution — On termite mounds in India and Malaysia (Baroni & Watling 1999). *Clitopilus orientalis* appears not to have been previously reported in Africa.

Comments — This particular *Clitopilus* species displays cheilocystidia and grows on termite mounds (Baroni & Watling 1999). The specimen examined differs from descriptions of the Asian species only in that cheilocystidia are abundant and sometimes clustered, rather than scattered. The most closely related species are *C. apalus* (Berk. & Broome) Petch, which has subglobose rather than ellipsoid spores, and *C. peri* (Berk. & Broome) Petch, which neither grows on termite mounds nor displays cheilocystidia (Pegler 1977, Baroni & Watling 1999).

Hymenagaricus subepipastus Heinem. & Little Flower, Bull. Jard. Bot. Nat. Belg. 54: 168, 1984. Plates 2, 3

Macrocharacters — Basidiomata small, gregarious. Pileus 0.5–1.2 cm diameter, at first convex, then trapezoid to flattened displaying dark olive-green [1E7, 30D7] scales on a light-green background [30A4], changes colour slightly during ageing, the background turns yellow [4A4] while the scales — though retaining their colour — become less abundant, since they are easily detached; margin thin, regular. Stipe central, fistulose, cylindrical, concolourous with pileus, whitish towards the base, up to 22 × 0.6 mm, surface pruinose to squamulose with scarce evanescent scales below ring zone, base

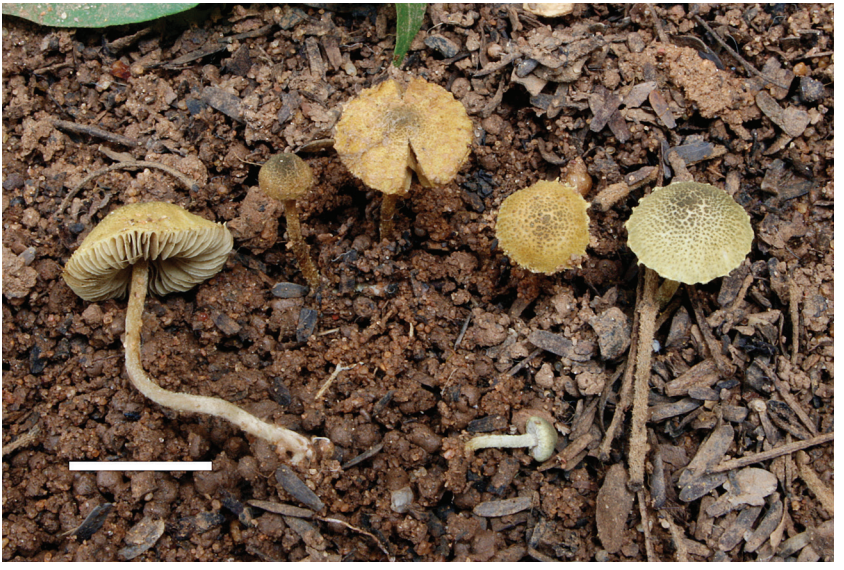

Plate 2. *Hymenagaricus subepipastus* (COFC-F 5186): Fresh basidiomata. Scale bar = 1 cm.

with white mycelial tufts. Ring absent or powdery and evanescent, seen only in very young specimens. Lamellae free, with lamellulae, 3–4/mm, greyish white at first [B2], then grayish yellow [1B2-3, 2B2-3], and finally brown [5C7], with paler crenulate margin. Spore deposit brown [5C7]. Context thin, fibrose, in stipe; odour and taste not recorded.

Microcharacters — Pileipellis made up of claviform, pyriform to spherical elements 7–17 × 7–16 µm grouped in chains and tufts forming a hymeniodermis, with thick walls and encrusted brownish orange pigments; subpellis made up of cylindrical elements, interwoven to subparallel, 3.5–8 µm, also with a thick wall and encrusted brownish orange pigments, becoming thinner, parallel and hyaline inwards. Stipitipellis formed by parallel cylindrical elements, 3–9 µm wide, often with chains of doliiform (barrel-shaped) to short-claviform terminal elements grouped in tufts; hyphae hyaline to yellowish brown, thin- to thick-walled, somewhat constricted at the septa. Context hyphae subparallel, cylindrical, 4–12 µm wide, thin-walled. Mycelial tufts with parallel cylindrical hyphae of 2–3.5(–5) µm wide, hyaline and thin-walled, sometimes with secretory hyphae, filled with refringent contents. Clamp connections absent in all structures. Cheilocystidia lageniform to fusiform, 16–20(–26) × (5–)6–10(–12) µm. Pleurocystidia absent. Basidia widely claviform, 12–15 × 5–7 µm, with (2)4 sterigmata, thin-walled. Spores ovoid to ellipsoid, smooth, brown coloured, thin to

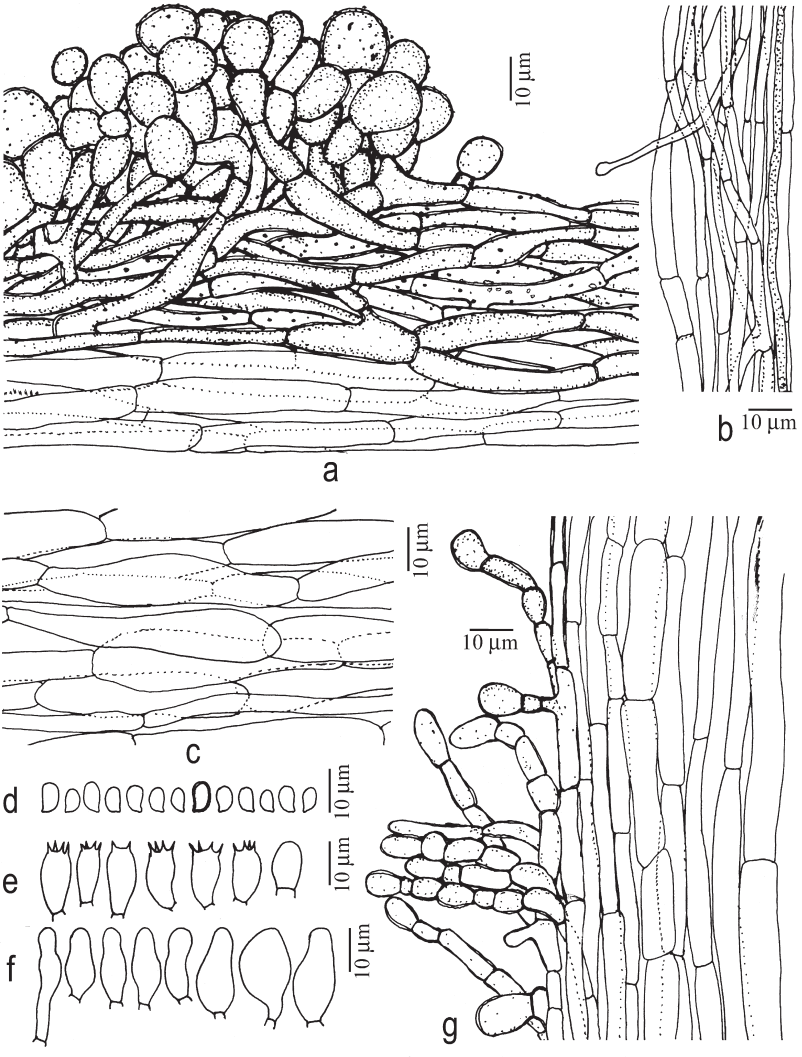

Plate 3. *Hymenagaricus subepipastus* (COFC-F 5186):
a) Pileipellis; b) Basal mycelium; c) Pileus context; d) Spores;
e) Basidia; f) Cheilocystidia; g) Stipitipellis.

thick-walled, (4–)4.5–6.3 × (2.7–)3–4(–4.5) µm, [Lm = 5.1 µm, Wm = 3.4 µm, E = 1.29–1.71; Em = 1.49].

Specimen examined — **NIGER, Niamey**, Niamey, Karadjé, guest house at Abdou Moumouni University, 13°29′25.5″N 2°04′64″E, elevation 200 m, in garden soil, 8 August 2010, P. Daniëls, Hama 383 (COFC-F 5186).

Ecology & Distribution — Scattered in the grass or garden soils. *Hymenagaricus subepipastus* was first described in India (Heinemann & Little Flower 1984), but Heinemann (1986) considered its presence in Africa likely. Our report may be the first record of the species in Africa.

Comments — Our specimen fully matches existing descriptions of *H. subepipastus* by Heinemann & Little Flower (1984). This species is related to *H. viridulus* Heinem. & Little Flower, but the spores of the studied collection are larger and ovoid rather than cymbiform (wineskin-shaped). *Hymenagaricus subaeruginosus* (Berk. & Broome) Heinem. & Little Flower has slightly smaller, cymbiform spores and larger basidiomata, with a pileus up to 4.5 cm diameter (Heinemann & Little Flower 1984). *Hymenagaricus epipastus* (Berk. & Broome) Heinem. & Little Flower differs from *H. subepipastus* only in spore size, and has been reported in Ceylon (Asia) (Heinemann & Little Flower 1984). For details see Table 2.

Table 2. Comparison of pileus and spores from species related to *Hymenagaricus subepipastus*.

Species	Pileus diam. (cm)	Lm	Wm	Spore shape
H. viridulus type [a]	0.5–1.5	4.7	3.3	Cymbiform
H. subaeruginosus isotype (K)	1.5–2.5 [b] / 4.5	4.7	3.2	Cymbiform
H. subaeruginosus MGF 5088 (BR)	1.5–2.5 [b]	4.5	3.0	Cymbiform
H. epipastus type [a]	2	4.2	3.1	Ovoid
H. subepipastus type [a]	1–1.5	5.0	3.6	Ovoid
H. subepipastus Hama 383	0.5–1.2	5.1	3.4	Ovoid

[a] Heinemann & Little Flower 1984; [b] measurements in exsiccatum

Termitomyces bulborhizus T.Z. Wei, Y.J. Yao, B. Wang & Pegler, Mycol. Res. 108: 1458, 2004. Plates 4–6

Macrocharacters — Basidiomata medium sized, gregarious. Pileus 4–12 cm diameter, fleshy, at first convex, then flattened and slightly depressed with obtuse blunt perforatorium 2–3 mm wide; white, isabella to olivaceous brown coloured [A1, 4A4, 4B6, 5A3] pallescent towards the margin and with brownish orange centre [6D5, 5B6-8]; surface smooth and dry or slightly viscose and radially rugose in wet conditions; margin thin, sinuous to sub-lobate, slightly involute when young then uplifted when old. Stipe central, cylindrical, straight, white to slightly isabella coloured [A1], (4–)7–11 × 0.5–2 cm, surface squamulose with evanescent recurved 2–3 mm long scales; bulbose at ground level of 2–3.5 cm diameter. Pseudorhizoid robust, rugose and grooved longitudinally, orange brown [4B5, 5C5, 6C8, 6B7] to black [5E3, 6F2-5, F1] downwards, of 5–20 cm long, tapering quickly towards the base. Lamellae

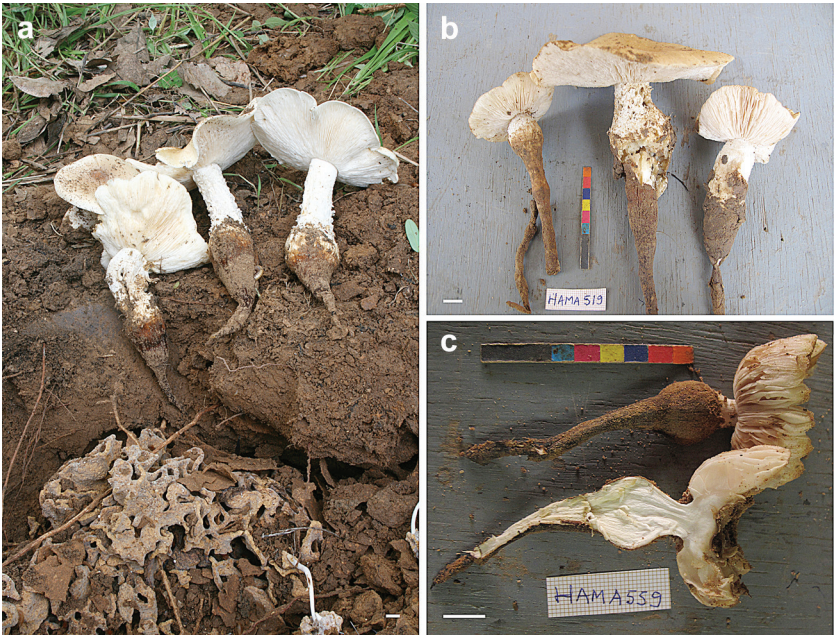

Plate 4. *Termitomyces bulborhizus*: fresh basidiomata:
a) COFC-F-5301; b) COFC-F-5305; c) COFC-F-5306. Scale bar = 1 cm.

free to almost free, with lamellulae, crowded, 8–12/cm, to 6 mm wide, white to slightly pink [A1, 6A2] with concolourous margin; spore deposit pink [6A2]. Context solid, fibrous, ≤1 cm in pileus; odour sometimes of fresh fish (taste not recorded). Termite mold ellipsoid, 10–20 cm long, grayish isabelline [4A5, 5C2] with irregular 0.5–1.5 cm wide holes.

Macrochemical reactions — KOH– in pileus; HCl+ dark yellow in pileus.

Microcharacters — Pileipellis made up of doliiform to cylindrical elements 6–17 × 3–9 µm, hyaline with thin wall, somewhat constricted at the septa; hyphal width increasing through context; parallel to interwoven forming a lax ixocutis-subtrichodermis. Pseudorhizoid formed by parallel cylindrical to doliiform elements, 4–15 µm wide in the external zone with often claviform to cylindrical terminal elements; hyphal width increasing through context to 15–35 µm wide, hyphae brown with thick wall, constricted at the septa. Stipitipellis similar to pseudorhizoid but hyphae hyaline, 3–5 µm wide in the external zone and 7–18 µm wide through context. Context hyphae cylindrical, 9–21 µm wide with thick 0.5–2 µm wall, and mixed with cylindrical hyphae 4–7 µm wide, with thin wall. Clamp connections absent

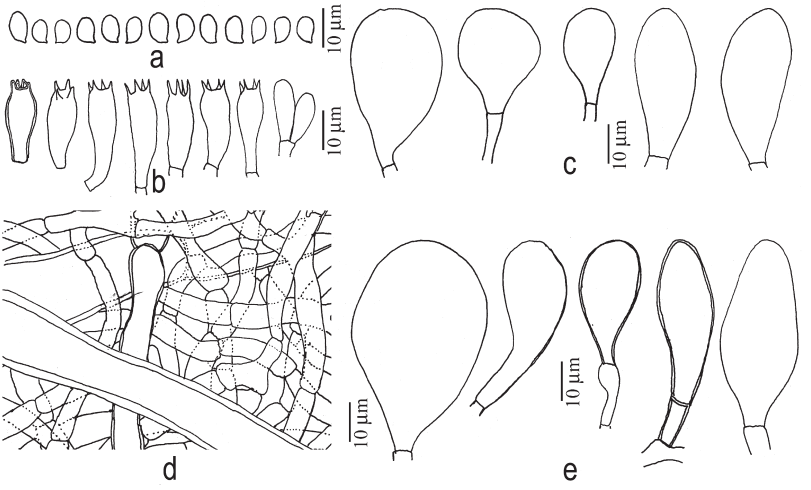

Plate 5. *Termitomyces bulborhizus* (COFC-F 5306):
a) Spores; b) Basidia; c) Cheilocystidia;
d) Pileus context; e) Pleurocystidia.

in all structures. Cheilocystidia claviform, fusiform to pyriform, (25–) 27–42 × (11–)13–24 µm. Pleurocystidia similar, sometimes with a secondary septum and/or thick wall, 28–56 × (10–)11–20(–35) µm. Basidia claviform, 18–24(–27) × 6–8.5 µm, with (2–)4 sterigmata and thin to, rarely, thick-walled. Spores ellipsoid, smooth, hyaline, thin-walled, (5.5–)6–7(–8) × (3–)3.8–4.4(–5) µm, [Lm = 6.4 µm, Wm = 4.1 µm, E = (1.38–)1.50–1.75(–1.80); Em = 1.56].

Specimens examined — **NIGER, Dosso**, Gaya, Gaya, Gorou Bassounga Forest, 11°54′00″N 3°24′25″E, elevation 209 m, savannah, on termite nest, 5 September 2010, O. Hama, Hama 443b (COFC-F 5302). **Tillabery**, Say, Tamou, Haoussa, 12°15′18″N 2°22′14″E, elevation 221 m, wooded *Afzelia africana* Smith ex Pers. savannah, on underground termite nest, 6 August 2010, O. Hama, Hama 286 (COFC-F 5301); 12°14′50″N 2°22′14″E, 24 August 2011, O. Hama, Hama 470 (COFC-F 5303); 25 August 2011, O. Hama, Hama 475 (COFC-F 5304); 12°14′51″N 2°22′15″E, wooded savannah of *Afzelia africana*, *Combretum glutinosum* Perr. ex DC., *C. collinum* Fres., with *Andropogon gayanus* Kunth, *Crossopteryx febrifuga* (Afzel. ex G. Don) Benth., *Strychnos spinosa* Lam., and *Flueggea virosa* (Willd.) Royle, on active termite nest, 15 August 2012, O. Hama, Hama 519 (COFC-F 5305); Say, Torodi, Gnaktiré, 12°59′01″N 1°44′32″E, elevation 237 m, cropland, under *Sclerocarya birrea* (A. Rich.) Hochst., on termite mound, 25 August 2010, O. Hama, Hama 405 (COFC-F 5095); 12°59′09.4″N 1°44′08.5″E, elevation 226 m, in a field of *Pennisetum glaucum* (L.) R. Br. and *Sorghum bicolor* (L.) Moench, close to *Balanites aegyptiaca* (L.) Delile, on a termite nest, 19 August 2012, O. Hama, Hama 559 (COFC-F 5306).

Ecology & Distribution — This taxon has been reported growing on termite nests in southern China (Sichuan, Yunnan) and Thailand (Wei et al.

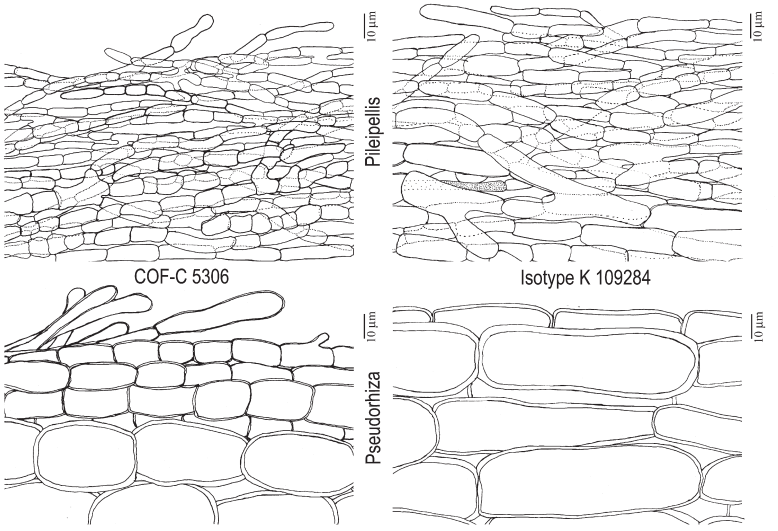

Plate 6. *Termitomyces bulborhizus*: comparison of pseudorhizoid and pileipellis from exsiccata COFC-F 5306 (left) and isotype K 109284 (right).

2004; Sawhasan et al. 2011). The associated termite species is identified as *Macrotermes barneyi* Light, native to Vietnam and southern China (Wang et al. 2009) and *Hypotermes makhamensis* Ahmad in the Thailand collection (Sawhasan et al. 2011). In this first African finding, the associated termite was *Macrotermes subhyalinus* (Rambur) (Koné, pers. comm.).

Comments — *Termitomyces bulborhizus* is a large mushroom with a characteristic black, swollen pseudorhizoid; the stipe surface appears slightly scaly due to the presence of fine floccules.

Our material differs slightly from the isotype of *T. bulborhizus* (K 109284) in the pileipellis structure that can be justified to different development stages of the fruitbodies. Due to the few notes regarding pileipellis and pseudorhizoid structure of this species, we consider showing them from both isotype and COFC-F 5306 (Plate 6). Descriptions of referred structures in the isotype are as follows: pileipellis made up of doliiform to cylindrical elements 8–45(–78) × 4–17 µm, hyaline with thin wall, somewhat constricted at the septa; hyphal width increasing through context; parallel to interwoven forming a subtrichodermis cutis; pseudorhizoid formed by parallel cylindrical to doliiform elements, 15–32 µm wide, hyphae brown with thick wall, constricted at the septa. The pseudorhizoid of the isotype was not clean enough for an accurate analysis so

we do not know enough to ascertain whether it might also have small hairs or claviform caulocystidia-like structures, as in the Nigerien sample. The bulbose stipe width in Nigerien samples was also smaller (<3.5 cm wide) than those given by Wei et al. (2004). Actually, Asian collections are bigger than African ones regarding basidioma size, with a pileus of (5–)10–22 cm (Wei et al. 2004).

Our material differs from *T. eurrhizus* (Berk.) R. Heim in having a dark-brown color and a swollen pseudorhizoid (Wei et al. 2004). In the most similar African species (*T. umkowaan* (Cooke & Massee) D.A. Reid and *T. subumkowaan* Mossebo) the stipe surface is smooth and the pseudorhizoid is not swollen. Also, *T. subumkowaan* bears two spores per basidium (Mossebo et al. 2002).

Plate 7. *Tulostoma evanescens* (COFC-F 5292): Exsiccatum. Scale bar = 1 cm.

Tulostoma evanescens Long & S. Ahmad, Farlowia 3: 235, 1947. Plates 7, 8

Macrocharacters — Basidiomata small, gregarious. Globose head 0.7–0.9 cm diameter. Exoperidium undefined, hyphal, thin, brown [5B4], intermixed with sand grains. Endoperidium membranous, smooth, white [A1]. Peristome circular and not prominent, white [A1] because of the absence of exoperidium around the mouth. Stipe cylindrical or tapering upwards, 1–1.3 × 0.2–0.3 cm, surface squamose with evanescent scales and longitudinally grooved, joined in the base to form a volva-like swollen structure in one basidioma; sometimes with rhizomorphs. Socket lacerate, with several small dentate membranes around the stipe. Gleba brown coloured [6C6]. Context firm, fibrous; odour absent and taste not recorded.

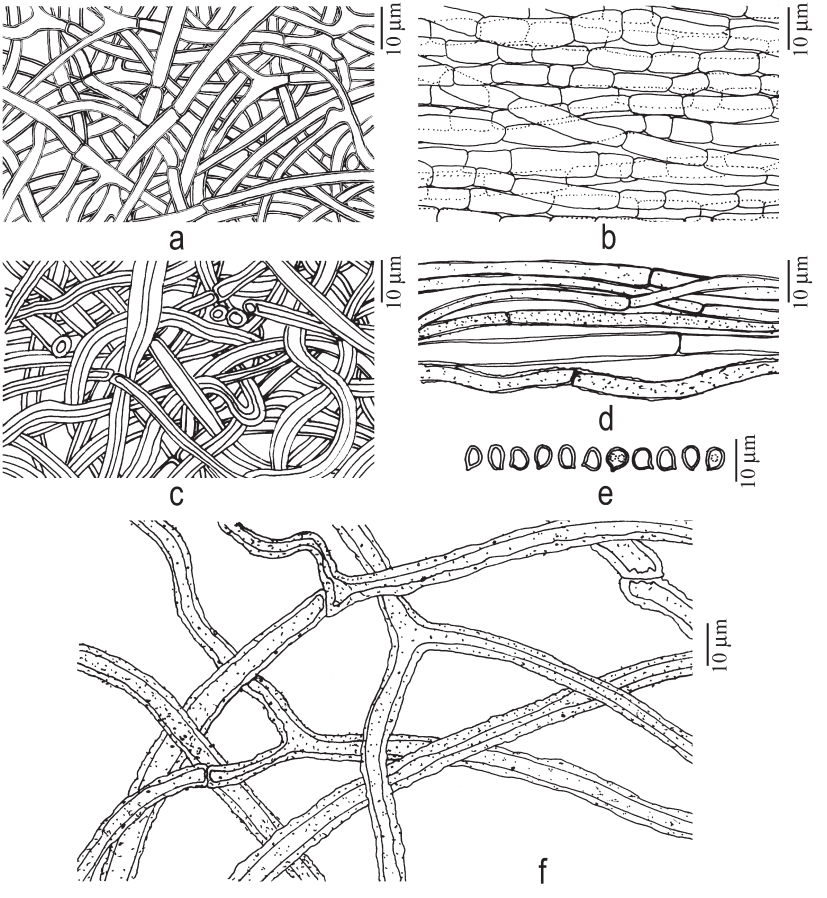

Plate 8. *Tulostoma evanescens* (COFC-F 5292):
a) Exoperidium; b) Context of stipe scales; c) Endoperidium;
d) Hyphae of rhizomorph; e) Spores; f) Capillitium.

Microcharacters — Exoperidium with cylindrical interlaced hyphae, 1.5–4 µm wide with, hyaline to brownish, moderate wall. Endoperidium similar, with hyphae 3–6(–8) µm wide, hyaline and with thick wall. Capillitium 3–8 µm wide, with lumen and thick wall minutely encrusted with granules, septate and with a few branches. Hyphae of stipe scales parallel, 4–6.5 µm wide, grouped in tufts; hyphae hyaline to yellowish, with thin wall, somewhat constricted at the septa. Hyphae of rhizomorph 2.5–7 µm wide, hyaline, often minutely encrusted with granules and with moderate wall.

Clamp connections absent in all structures. Basidia not seen. Spores ovoid to ellipsoid, smooth, brown coloured, thick-walled, some apiculate, (4.7–) 5–5.4(–6) × (3.7–)4–4.5(–5) µm, [Lm = 5.2 µm, Wm = 4.1 µm, E = 1.11–1.38; Em = 1.26].

Specimen examined — **NIGER, Tillabery**, Say, Tamou, Tamou Total Faunal Reserve {Tamou Reserve}, 12°34′21″N 2°18′28″E, elevation 240 m, wooded savannah, humus-containing sandy soil, 7 August 2010, O. Hama, Hama 361 (COFC-F 5292).

Ecology & Distribution — This species grows in arid sites and appears after rains in copious quantities. According to Wright (1987), this species has been reported in India and Argentina. This appears to be the first report of this species in Africa.

Comments — The material examined here agrees with earlier descriptions, including the following features: 1) Clearly-defined circular, tubular, or flat peristome on a head of ≤1 cm in diameter; 2) smooth subglobose or ellipsoid spores measuring about 5–5.4 × 4–4.5 µm; 3) inconspicuous hyphal exoperidium; and 4) capillitium 4–10 µm wide.

Tulostoma operculatum Long & S. Ahmad has smaller (4–4.7 µm diam.) spores and a fimbriate mouth. *Tulostoma brevistipitatum* B. Liu et al. does not have a volvoid structure at the stipe base, and its spores are slightly longer (5.4–6.1 × 4.3–5 µm). *Tulostoma fusipes* Har. & Pat. is very similar, but its spores are globose, the capillitium is coloured, and the stipe is longer (5.5 × 0.4 cm) (Wright 1987).

Volvariella* cf. *sathei Senthil., Rahul Sharma & S.K. Singh, Mycotaxon 119: 470, 2012. Plates 9, 10

Macrocharacters — Basidiomata medium sized, gregarious. Pileus 3.5–12(–15) cm diameter, fleshy, convex; white to isabella [A1, 4A2]; surface fibrillose; margin exceeding the lamellae, eroded, or striate with triangular tufts. Stipe central, fistulose when aged, cylindrical and tapering towards apex, straight, concolourous with pileus, 5–12 × 1–2 cm, surface glabrous to fibrillose; slightly bulbose. Volva membranous, 1–5 × 2–4 cm and 1–1.5 mm thick, white [A1], sometimes with grayish brown hue [4C3]. Lamellae free, distant from stipe, with lamellulae, crowded, (10–)13–16(–17)/cm, 3–5 mm wide, at first whitish [A1, 3A2] then pink [9A2, 14A3] with paler, dentate to fibrillose margin. Spore deposit pink [9A3, 10B5]. Context solid, fibrous; odour disagreeable, farinaceous to fruity, and pleasant taste.

Macrochemical reactions — KOH– or NaOH– in pileus, context or stipe.

Microcharacters —Pileipellis made up of cylindrical elements 8–21 µm, hyaline with thin to thick wall, somewhat constricted at the septa; parallel, forming a regular cutis. Stipitipellis similar to pileipellis, hyphae

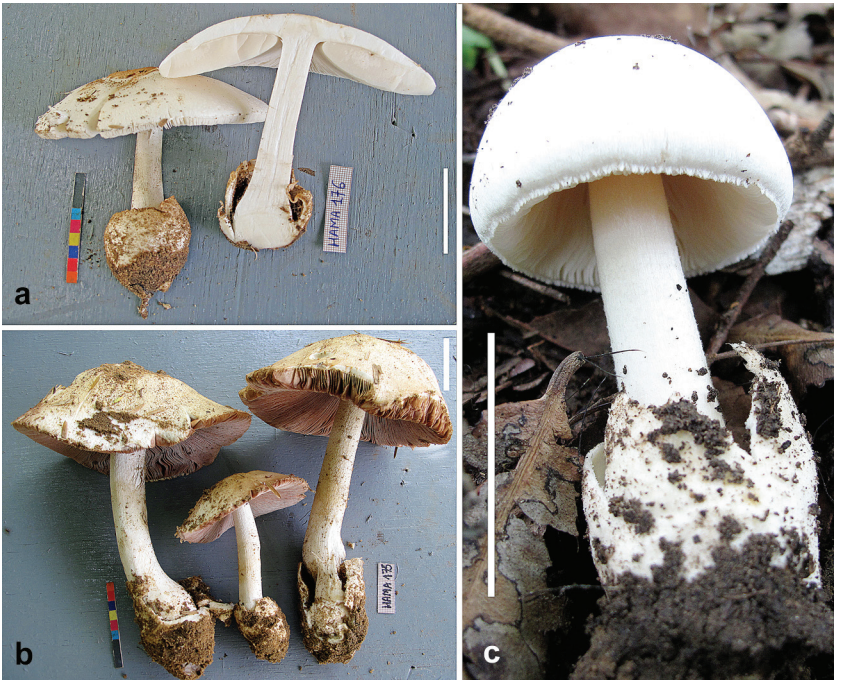

Plate 9. *Volvariella* cf. *sathei*, fresh basidiomata:
a) COFC-F-5092; b) COFC-F-5036; c) COFC-F-5033. Scale bar = 3 cm.

hyaline, 4–15 µm wide in the external zone and up to 35 µm wide through context. Context hyphae cylindrical, 8–21(–28) µm wide with thin wall. Volva composed mostly of cylindrical hyphae, 3–5 um wide with scattered inflated elements, cylindrical, fusiform or irregularly shaped, up to 20 um wide. Basal tomentum formed by interlaced cylindrical elements, 5–22 µm wide; hyaline with thin to thick wall. Clamp connections absent in all structures. Cheilocystidia fusiform to lageniform, 40–88(–95) × 10–38 µm, with hyaline thin wall, sometimes with a basal secondary septum. Pleurocystidia similar, 39–80 × 11–24 µm. Subhymenium cellular, with ellipsoid to doliiform hyphae, 10–20 µm in diameter. Basidia claviform, (19–)22–27(–30) × 7–9 µm, with (2–)4 sterigmata and thin-walled. Spores globose to ob-triangular, smooth, brownish pink, thick-walled, (5–)5.6–6(–7) × (4.5–)5.1–5.7(–6.7) µm, [Lm = 5.8 µm, Wm = 5.4 µm, E = 0.92–1.40; Em = 1.07].

Specimens examined: **NIGER**, **Niamey**, Niamey, Abdou Moumouni University, Faculty of Agricultural Sciences, experimental garden, 13°30′00.5″N 2°05′24.5″E, elevation 178 m, in a disturbed area, growing on plant residue under *Prosopis juliflora* (Sw.) DC., 6 August 2009, O. Hama, det. A. Justo, Hama 175 (COFC-F 5036); sandy

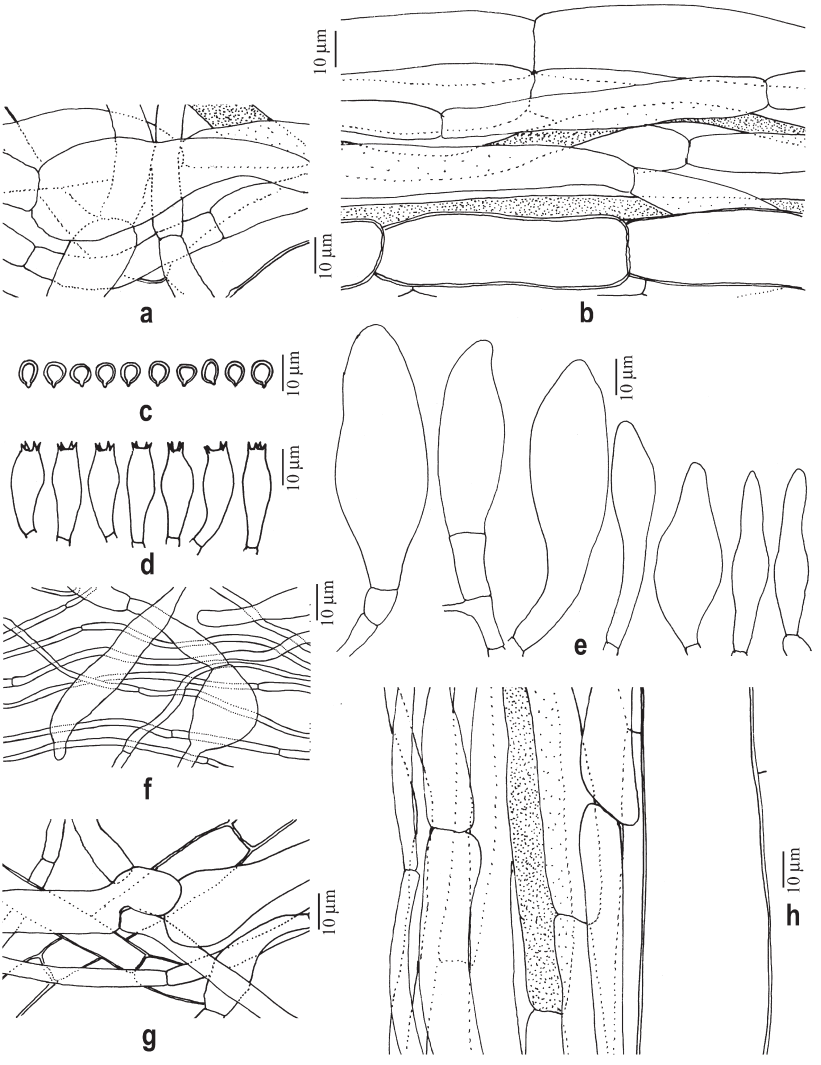

Plate 10. *Volvariella* cf. *sathei* (Figs a–e, g–h from COFC-F 5448; Fig. f from COFC-F 5033): a) Pileus context; b) Pileipellis; c) Spores; d) Basidia; e) Cheilocystidia; f) Volva, g) Basal tomentum, h) Stipitipellis.

soil with cattle manure under *Prosopis juliflora*, O. Hama, Hama 176 (COFC-F 5092); Niamey, Abdou Moumouni University, High School of Education, 13°30′07″N 2°05′29″E, elevation 187 m, in a disturbed area, in sandy soil near *Azadirachta indica* A. Juss., 4 August 2010, O. Hama, det. A. Justo, Hama 390 (COFC-F 5088; Genbank KF926666). **Tillabery**, Say, Torodi, Fayra, 13°01′26.7″N 1°45′39.4″E, elevation 232 m, in arable fields with plant residue of *Piliostigma reticulatum* (DC.) Hochst., 21 August

2008, O. Hama, Hama 38 (COFC-F 5448); Say, Torodi, Gnaktiré, 12°59′02″N 1°44′49″E, elevation 222 m, cropland, growing on organic residue near houses with *Pennisetum glaucum* and *Sorghum bicolor*, 16 August 2009, O. Hama, det. A. Justo, Hama 194 (COFC-F 5034; Genbank KF926664); 12°59′01″N 1°44′32″E, elevation 221 m, in arable fields on heaped-up plant residue with *Sorghum* and *Pennisetum*, 15 August 2009, O. Hama, det. A. Justo, Hama 193 (COFC-F 5035; Genbank KF926663); Say, Tamou, Mékrou, {W National Park}, 12°15′16″N 2°23′24″E, elevation 218 m, in gallery forests with *Cola laurifolia* Mast., *Diospyros mespiliformis* Hochst. ex A. DC., *Mitragyna inermis* (Willd.) Kuntze, on sandy-clay soils, 22 August 2009, O. Hama, Hama 204, det. A. Justo (COFC-F 5033; Genbank KF926665).

Ecology & Distribution — The authentic species, *Volvariella sathei*, was recently proposed, based on Indian material (Senthilarasu et al. 2012), and has not been reported elsewhere.

Comments — The large white species, *V. sathei*, differs from *V. nivea* T.H. Li & Xiang L. Chen in having ovoid to widely ellipsoid spores and larger cystidia (Senthilarasu et al. 2012).

Our samples agree mostly with the description given by Senthilarasu et al. (2012) except for: (1) the presence of fusiform to lageniform cystidia (cylindro-clavate in *V. sathei*); (2) spores often with a triangular shape; and (3) grayish hue sometimes present in volva. Molecular analysis indicates that the African isolates are in the same clade as the Indian *V. sathei* but that there are some differences between them (Plate 11). Additional data are needed to confirm whether the African isolates represent *V. sathei* or a closely related taxon.

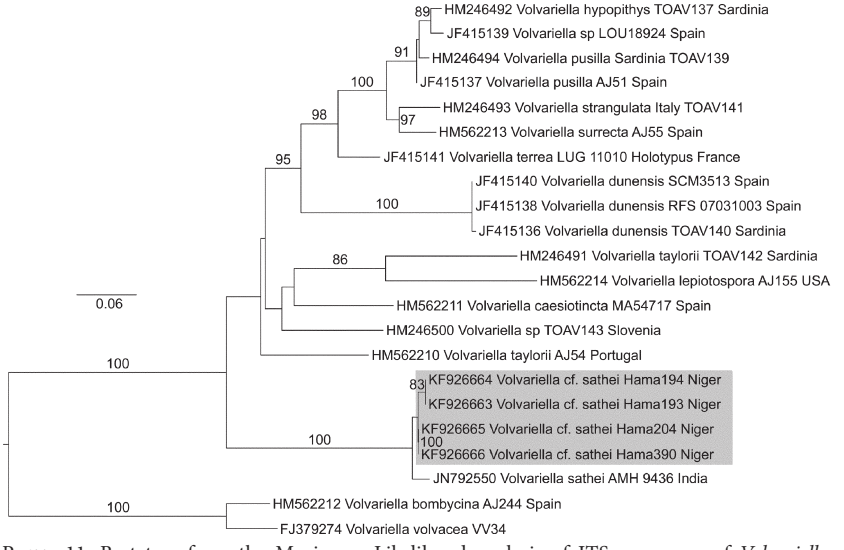

Plate 11. Best tree from the Maximum Likelihood analysis of ITS sequences of *Volvariella*. Nigerien samples of *V*. cf. *sathei* are emphasized. Scale bar indicates nucleotide substitutions/site.

Discussion

The taxa examined here are species previously recorded in Asia; this is the first time they have been reported on the African continent. Fungal species common to both continents are frequently reported, perhaps due to climatic and/or ecological similarities, spore dispersal capacity, and shared geological history; cases of vicariance and species fragmentation are also found (Berndt 2002, O'Donnell et al. 2011, Geml et al. 2008, Moncalvo & Buchanan 2008). The fragmentation of biogeographical ranges may sometimes be due to human intervention and particularly to the introduction of exotic plant species with their own associated fungal suites (Niveiro et al. 2009, Chen et al. 2006, Read 2000, Pringle et al. 2009); some ectomycorrhizal fungi entered Africa by this means (Duponnois & Galiana 2007, Garbaye et al. 1988). The climate of the West Sudanian savannah is similar to that of the Asian savannah of India, Laos, Thailand, Myanmar, Vietnam, and Cambodia (Young & Solbrig 1993). There are, however, differences in floral composition, with *Dipterocarpaceae* predominating in Asia and *Leguminosae* in Africa. This can help to discriminate some tree-restricted ectomycorrhizal species better than saprobes. However, there are some wide-ranging mycorrhizal fungi, which could also suggest a lack of fungal sampling in this ecosystem type (*Tulostoma evanescens* might represent such a case). Actually, infrequent sampling of the African savannah may have led to a bias in our knowledge of the biogeographical range, substrate versatility, spore dispersal capacity, and ecological similarity of these species. Furthermore, some saprobic species are often unspecific regarding substrate degradation and sometimes the substrate itself is originated by fire or domestic herbivore digestion, reducing substrate differences between distant geographic areas.

Mushrooms associated with termite nests grow only where termites are found. Several termite genera and species (e.g. *Macrotermes*, *Microtermes,* and *Odontotermes*) are common to both continents (Cheng and al. 2011) and this kind of mycological association seems to have originated in West Africa (Nobré et al. 2011). *Clitopilus orientalis* is a saprobic fungus with an apparent preference for termite nests.

Our discoveries provide a promising basis for further research into Niger's fungal diversity. Many collections are yet to be reviewed, and their examination will doubtless enhance our knowledge of fungal diversity in the West Sudanian savannah as a whole, and also enable a closer appraisal of its similarity with its Asian counterpart. More samples and DNA-analysis of the studied material are needed to discern cryptic species, and *Volvariella* cf. *sathei* may be a geographic variety of the Asian species.

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